3M: Hutchinson Plant Focuses on Heat Recovery and Cogeneration during Plant-Wide Energy-Efficiency Assessment

Benefits

- Identifies savings of an estimated 6 million kWh/yr in electricity and more than 200,000 MMBtu/yr in natural gas and fuel oil
- Identifies methods of avoiding energy costs of more than $1 million during the first year
- Identifies 2-year payback period

Application

The 3M plant-wide energy-efficiency assessment focused on the technical and economic evaluation of existing energy systems and operations that could benefit from heat recovery and cogeneration opportunities. This assessment revealed opportunities to replicate efficiency improvement projects at other tape manufacturing facilities and at facilities that use thermal oxidizers for VOC destruction.

Summary

3M undertook a plant-wide energy-efficiency assessment at its Hutchinson, Minnesota, plant to identify opportunities specific to that plant's operations and utility requirements, yet potentially applicable to similar plants and processes in other regions of the country. Assessment staff developed four separate implementation packages that represented various combinations of energy-efficiency projects identified during the assessment. One package was chosen for implementation based on relative aggregate payback periods of the individual packages. This package included projects for chiller consolidation, air compressor cooling improvements, a steam turbine used for cogeneration, and a heat recovery boiler for two of the plant's thermal oxidizers. Staff estimated that the plant could save 5.7 million kilowatt-hours per year (kWh/yr) in electricity and 214,499 million British thermal units per year (MMBtu/yr) in natural gas and fuel oil by implementing the energy savings measures included in the package. Specific projects identified during the assessment are applicable to other tape manufacturing facilities and to facilities that use thermal oxidizers for volatile organic compound (VOC) destruction.

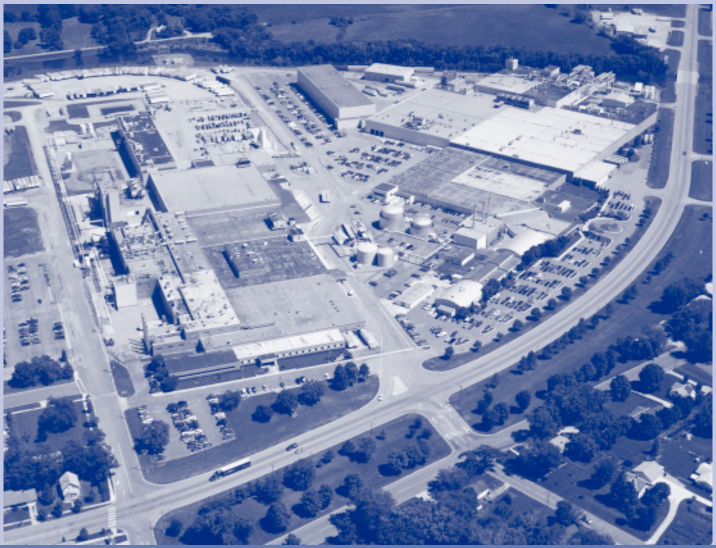
DOE-Industry Partnership

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment through a competitive process. DOE promotes plant-wide energy-efficiency assessments that will lead to improvements in industrial energy efficiency, productivity, and global competitiveness, while reducing waste and environmental emissions. In this case, DOE contributed $48,580 of the total $97,161 assessment cost.

Company Background

3M was founded in 1902 as the Minnesota Mining and Manufacturing Company in Two Harbors, Minnesota. Throughout its history, 3M has developed and manufactured a vast variety of products, including waterproof sandpaper, adhesives, building materials, magnetic tape, photographic products, carbonless papers, medical and dental products, and office products. Today, 3M is a $16-billion diversified technology company with markets in health care, safety, electronics, telecommunications, industry, and consumer and office supplies. 3M operates companies in more than 60 countries and serves customers in nearly 200 countries.

3M bought the Hutchinson, Minnesota, plant after World War II, when the U.S. Government no longer needed it to manufacture hemp products. The facility subsequently began producing 3M's Scotch brand cellophane tape. Since then, it has produced a variety of the company's consumer, office, industrial, and electrical supplies and tapes. After expansion to accommodate new product lines and manufacturing processes, Hutchinson is now the largest 3M manufacturing site in the United States. The plant covers 1.3 million square feet, employs more than 1,600 workers, and consists of two buildings (the north and south buildings). The annual energy expense at the plant is about $7 million.



3M's Hutchinson Plant

A central steam plant serves the entire facility's needs for heat, hot water, and process loads. Primary and secondary fuels for steam production are #6 oil and natural gas. High-pressure steam (190 psig) is required to recover solvent; other plant loads use 15-psig steam. Compressed air is used for pneumatic control of the HVAC system, actuation of process components, and for production processes.

Assessment Approach

The plant-wide energy-efficiency assessment focused on the technical and economic evaluations of existing energy systems and operations that could benefit from process heat recovery and/or cogeneration. Assessment staff evaluated the supply-side utility infrastructure, demand-side energy systems, process controls, and production systems.

In 2001, electricity represented about 26% of the plant energy requirements and 56% of the annual expense for purchased energy and utility services. Chilled water production accounted for about 16% of electric energy consumption. Interruptible natural gas and fuel oil used for steam production accounted for 54% of the annual energy consumption and 26% of annual expense for purchased energy and utility services. Firm natural gas represented about 20% of annual energy consumption and about 15% of purchased energy and utility services expense. Therefore, assessment staff reasoned that energy-efficiency measures affecting electric consumption and steam production would provide the greatest potential benefit to plant operations.

The plant-wide energy assessment at 3M Hutchinson primarily focused on heat recovery, heat utilization, and cogeneration opportunities. Assessment staff primarily studied the plant's thermal oxidizers and air compressors. Cogeneration potential was assessed because the site has fairly constant electrical and steam demands. Staff evaluated cogeneration opportunities using either a combustion turbine or a reciprocating engine. Because of the high operating costs of the thermal oxidizers, staff also evaluated alternatives to thermal oxidizers for VOC destruction. Steam systems were reviewed for design, thermal insulation, and physical condition.

Results

Assessment personnel identified four separate implementation packages comprising various combinations of energy-efficiency measures. Packages were developed separately because some of the individual efficiency improvement measures involving the thermal oxidizer units were mutually exclusive. The package recommended for implementation had the shortest payback period. This package involved recovering heat from the 1L and 3L thermal oxidizers' exhaust to produce low-pressure steam, which would offset the fuel requirements of plant steam production. Although the assessment team did not recommend immediate implementation of the packages involving combustion turbine-based cogeneration to destroy VOCs, it was suggested that research on the technical feasibility of these measures be continued. Such an application could help manage plant emissions while simultaneously improving its energy efficiency.

Efficiency improvements identified through the survey will provide benefits beyond the immediate energy savings at the plant. Interconnection and consolidation of the chillers will improve the plant's cooling efficiency and will also improve the reliability of chilled water production. To the extent that some process loads depend on chilled water, the plant's implicit productivity will also improve because process loads will not have to be reduced if a chiller fails.

The heat recovered for steam production will improve the thermal efficiency of the thermal oxidizer, reducing boiler fuel consumption and environmental emissions. Using a steam turbine to reduce steam pressure will also offset the plant's retail electric requirements.

Table 1 shows the recommended energy-efficiency measures and their corresponding estimated energy and cost savings.

Table 1. Recommended Energy-Efficiency Measures

	Energy Savings				
Project	**Electricity (kWh/yr)**	**Natural Gas (MMBtu/yr)**	**#6 Oil (MMBtu/yr)**	**First Year Avoided Energy Expense ($)[1]**	**Project Capital Cost ($)**
Chiller consolidation	1,552,750	N/A	N/A	87,420	292,545
Air compressor cooling, North Plant	609,000	N/A	N/A	22,168	65,340
Air compressor cooling, South Plant	393,750	N/A	N/A	34,287	170,775
Thermal oxidizer heat recovery boiler	N/A	38,093	172,557	772,191	913,275
Steam turbine	3,166,000	N/A	N/A	163,999	604,035
Relative humidity	N/A	695	3,145	14,200	0
Total	**5,721,500**	**38,788**	**175,702**	**1,094,265**	**2,045,970**

[1]Savings for subsequent years may vary, depending on energy costs.

Projects Identified

The following are individual energy-efficiency measures identified during the plant-wide assessment that are scheduled to be implemented as a package. Because of the similarity of design and operation between Hutchinson and other manufacturing facilities, the specific projects identified during the assessment can be replicated at other tape manufacturing facilities and at facilities that use thermal oxidizers for VOC elimination.

Cooling—Chiller consolidation.

The total capacity of the chilled water system is 7,640 tons for both the north and south plants. Electric energy savings could be realized by consolidating the chiller capacity of both plants. This could be accomplished by interconnecting the individual chilled water distribution systems serving the plants. Through consolidation, the newer and more efficient chillers of the north plant could be used for base loads. These chillers would then serve larger loads for longer periods, lowering operation costs. It is estimated that chiller consolidation would yield energy savings of more than 1.5 million kWh/yr.

Cooling—Air compressor cooling, north and south plants.

The air compressors of the north and south plants currently use chilled water for cooling. The nominal chilled water demand for cooling the north and south air compressors is 145 tons and 75 tons, respectively. The cooling towers of the chilled water system could be used as the primary cooling method for the air compressors. The potential energy savings are equal to the differential between chiller operation and operation of circulating pumps. It is estimated that electricity requirements would be reduced by 609,000 kWh/yr in the north plant and 393,750 kWh/yr in the south plant by implementing this measure.

Heat Recovery—Thermal oxidizer heat recovery boiler.

The 2L thermal oxidizer has a regenerative/recuperative cycle, thereby reducing exhaust temperature and effectively eliminating the unit as a potential source for heat recovery. Units 1L and 3L are suitable candidates for heat recovery applications. Two applications were considered: an oil-to-air heat exchanger to preheat supply air and makeup air, and a heat recovery boiler for low-pressure steam production.

Because the payback period of the heat recovery boiler is much shorter than for the heat exchanger (1.2 years vs. 8.1 years), the heat recovery boiler is the recommended option. Using a reheat boiler as the heat recovery mechanism also mitigates the heat recovery limitations of an oil-to-air heat recovery system. With the oil-to-air system, the annual energy reduction is limited to the load of the specific air-handling units. Heat recovered from the thermal oxidizers for producing low-pressure steam has greater potential savings because the steam can serve loads throughout the plant. Annual steam production from the heat recovered from the two thermal oxidizers is estimated to be more than 164,000 million pounds per year. Estimated energy savings are more than 210,000 MMBtu/yr because of the reduced need for natural gas and fuel oil.

Cogeneration–Steam turbine.

Steam is produced at a nominal pressure of 220 psig, but the steam pressure is reduced to 125 psig and 15 psig for process loads and humidification, respectively. Using the pressure drop to drive a steam turbine and an electric generator rather than reduction through a pressure reducing valve could provide an offset in the retail electric service requirements of the plant. Replacing the existing pressure-reducing valve with a steam generator represents an opportunity for cogeneration in this case. It is estimated that this measure will save more than 3 million kWh/yr in electricity.

Steam System—Relative humidity project.

Steam provides the plant's relative humidity. Corporate guidelines have stipulated that relative humidity levels of 50% are necessary for the types of materials and processes used at the Hutchinson plant. Re-analysis has determined that an acceptable range is now 35% to 40%. Accordingly, steam production can now be reduced to correspond to this allowable range. No capital investment is necessary for this project.

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PROJECT PARTNERS

3M
Hutchinson, Minnesota

Sebesta Blomberg & Associates
Roseville, Minnesota

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

Industrial Technologies Clearinghouse
Phone: 800-862-2086
Fax: 360-586-8303
clearinghouse@ee.doe.gov

Visit our home page at
www.oit.doe.gov

Industrial Technologies Program
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121

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